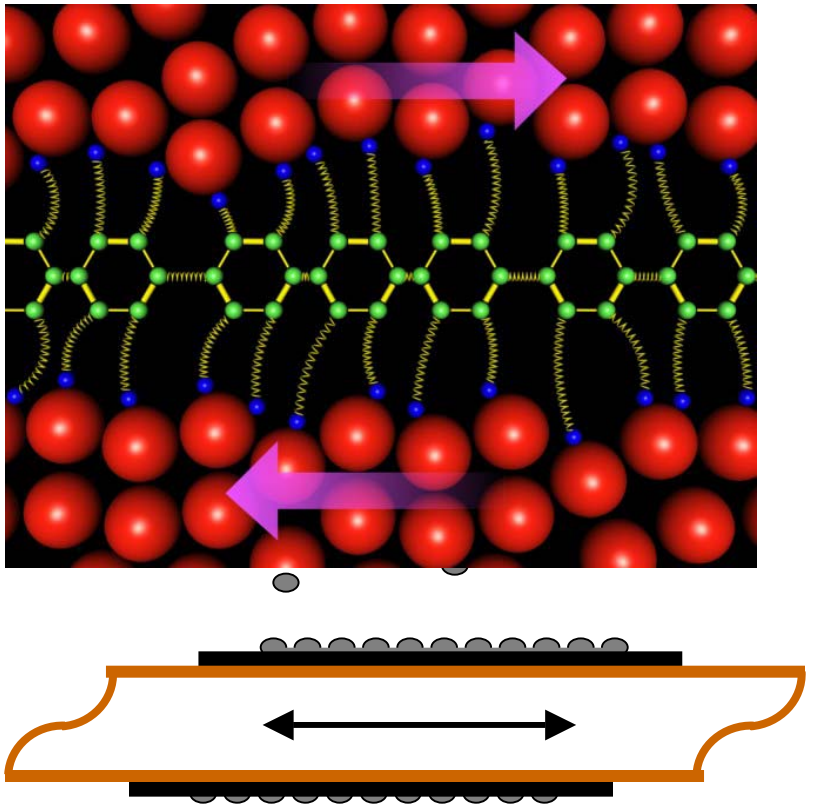
Quartz Crystal Microbalance Studies of Atomic-Scale Friction
Jacqueline Krim, National Science Foundation, DMR0320743

Nanotribology

Our research program is unique world-wide, exploring the nano-scale origins of friction with a quartz crystal microbalance technique that the PI developed in the late 1980's with the support of NSF.

This year we published the first direct link between nanoscale dynamics and macro scale friction coefficients, in M. Abdel-maksoud, J. Bender and J. Krim, *Physical Review Letters*, 92, Art# 176101 (April 2004)



Top: Reaction films that vibrate for *picoseconds* during sliding are linked to low friction coefficients. Rigid reaction films yield high coefficients and lubricant failure.
Bottom: The Quartz Crystal Microbalance

As engineers and scientists race to design the nanomachines predicted to revolutionize the future of everything from manufacturing to health care, they must understand friction at the atomic scale or their devices won't survive the heat they generate. Both heat and wear could inflict mortal wounds on nanomachines, where melting or shearing off a surface layer of atoms could render the entire device useless.

Jacqueline Krim is the director of the Nanotribology Laboratory at North Carolina State University, with three graduate students and two undergraduate students supported by DMR0320743. Nanotribology (from the Greek *tribo*, to rub), the study of friction at atomic length and time scales, is such a new science that Krim herself coined the term in 1986.

At the atomic scale, friction has very little to do with surface roughness, and the technology has crashed head-on with fundamental physics and chemistry. This year Krim published the first report (PRL, 2004) of how the macroscopic friction coefficient of a lubricant is linked to the nanodynamical motion of the molecules in the lubricant. The group was astonished to discover that a difference in how the molecules flexed and slipped *after* being firmly attached to a surface was linked to what is observed at the macroscale. The flexing motion was monitored a the level of picoseconds, (*one millionth of a millionth of a second!!),* and the group observed that only miniscule motion at this time scale was sufficient to allow sliding of contact points and dramatic reduction in macroscopic friction.

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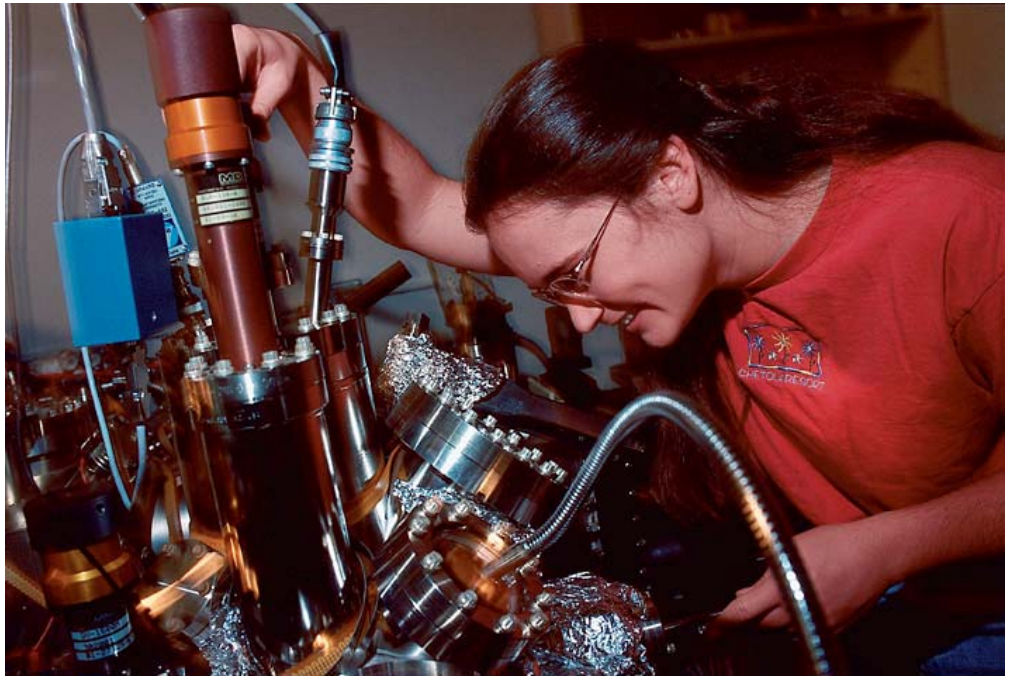

Congratulations to Tonya Coffey, Ph.D. awarded July 2004, thesis entitled *Nanotribology Fundamentals: Predicting the Viscous Coefficient of Friction*
Current Position: Assistant Professor, Appalachian State University, Boone, NC
3 graduate students and two undergrads are currently supported by DMR0320743

Krim's research on Nano-tribology was featured in the August 2003 issue of *Popular Mechanics*